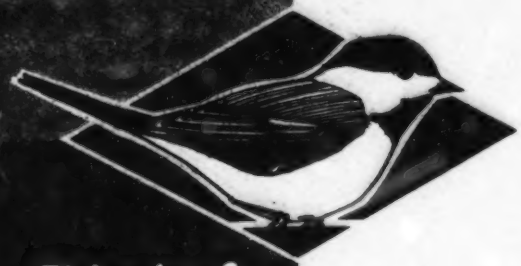

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RESOURCE STATUS AND
ASSESSMENT BRANCH

Status of the Black-throated Green Warbler (Dendroica virens) in Alberta

Michael R. Norton

Alberta Wildlife Status Report No. 23

Alberta Conservation
Association

Alberta

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PREFACE

Every five years, the Fisheries and Wildlife Management Division of Alberta Natural Resources Service reviews the status of wildlife species in Alberta. These overviews, which have been conducted in 1991 and 1996, assign individual species to 'colour' lists that reflect the perceived level of risk to populations that occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily available sources of population data. A primary objective of these reviews is to identify species that may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the 1996 *Status of Alberta Wildlife* review process, and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are potentially at risk in the province (Red or Blue listed), that are of uncertain status (Status Undetermined), or which are considered to be at risk at a national level by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Reports in this series are published and distributed by the Alberta Conservation Association and the Fisheries and Wildlife Management Division of Alberta Environment, and are intended to provide detailed and up-to-date information which will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide current information which will assist the Alberta Endangered Species Conservation Committee to identify species that may be formally designated as endangered or threatened under the Alberta Wildlife Act. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

EXECUTIVE SUMMARY

The Black-throated Green Warbler (Dendroica virens) is currently on the "Blue List" of species that may be at risk in Alberta, because of concerns over habitat loss and population declines in some areas. This report summarizes available information on the Black-throated Green Warbler, as a step towards updating the status of this species in the province.

The Black-throated Green Warbler is a neotropical migrant that breeds in the Boreal and Foothills regions of Alberta. The Black-throated Green Warbler requires forest stands that are at least 80 years old and peak densities of birds, in most areas, occur in stands that are 100-130 years old. Mixed stands comprised of White Spruce (Picea glauca) and Trembling Aspen (Populus tremuloides) or Balsam Poplar (Populus balsamifera) are typical of this species' habitat in Alberta.

The principal limiting factor for the Black-throated Green Warbler in Alberta is the loss and degradation of its breeding habitat. Forestry and energy sector activities are causing habitat loss and fragmentation and silvicultural practices and government policy currently promote the harvesting of older stands, and an 'unmixing' of mixedwood stands. Future projections of rates of resource extraction in Alberta call for these activities to increase. Although Canadian populations of the Black-throated Green Warbler are thought to have remained fairly stable over the past 30 years, recent evidence suggests that numbers will decline in disturbed areas. Habitat loss in wintering areas will likely exacerbate this situation.

The Black-throated Green Warbler remains a relatively common songbird in suitable habitat across much of Alberta's boreal forests. However, the rate of loss of the species' breeding habitat is cause for concern and sufficient evidence exists to support a recommendation to modify management of Alberta's forests to ensure the continued availability of suitable habitat. Robust, longer-term data sets and a better understanding of the habitat requirements of the Black-throated Green Warbler is needed to adequately assess population levels and trends in Alberta and to monitor effects of resource extraction on the species.

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INTRODUCTION

The Black-throated Green Warbler (Dendroica virens) is a neotropical migrant. The species breeds across the boreal forests of Canada and the north-eastern United States, and winters in Mexico and Central America. Although common in some areas of suitable habitat in Alberta, little is known about its ecology in the province. Recent concerns over the degradation and loss of its breeding habitat through forest harvesting have led to the Black-throated Green Warbler being included on the 'Blue List*' of species that may be at risk of extirpation in Alberta (Alberta Wildlife Management Division 1996).

This report summarizes historical and recent information on the Black-throated Green Warbler in Alberta in an effort to update its status in the province.

HABITAT

In general, descriptions of the habitat of the Black-throated Green Warbler emphasize an association with coniferous tree species in mature forests (Morse 1993). However, across its breeding range the Black-throated Green Warbler exhibits fairly broad patterns of habitat use (Collins 1983). In Canada, it has been described as characteristic of the most fertile needle-leafed forest community present in a region (Erskine 1977). In Alberta, records for the species exist from the Boreal Mixedwood, Boreal Foothills, and Boreal Uplands Ecoregions (see Strong and Leggat 1981). Recent work has revealed two consistent features of the Black-throated Green Warbler's habitat in Alberta:

- deciduous- or coniferous-dominated mixedwood, with a dependence on the presence of some mature coniferous trees in the forest canopy
- older stands; perhaps 80-130 years old or older.

General habitat descriptions for the Black-throated Green Warbler have been published from across its range, including Ontario, Quebec, Maine, New Hampshire, Minnesota, and British Columbia. The species is fairly plastic in its habitat requirements at a continental scale, and has been described in association with a variety of coniferous stands (Bent 1953, Collins et al. 1982, Collins 1983), and specifically with Balsam Fir (Abies balsamea) and Hemlock (Conium maculatum) stands (Erskine 1977). Mixed coniferous-deciduous stands have been frequently described including pine-aspen (Welsh and Lougheed 1996), spruce-aspen and spruce-poplar (Enns and Siddle 1996, Cooper et al. 1997).

In almost all cases, the Black-throated Green Warbler is classified as a forest specialist: it inhabits larger tracts of forest and tends to avoid disturbed or edge habitats and small forest patches (e.g., Erskine 1977, Darveau et al. 1995). Recent work in Alberta reveals a consistent association of the Black-throated Green Warbler with deciduous- or coniferous-dominated mixedwood, with a dependence on the presence of some coniferous canopy trees.

Black-throated Green Warblers in Alberta are typically found in mixed stands of Trembling Aspen (Populus tremuloides) and White Spruce (Picea glauca). Both aspen-dominated and spruce-dominated stands are used (Bighorn Environmental Design Ltd. 1998, Norton et al. in review, B. Beck, unpubl. data, L. Takats, unpubl. data). Most records from an extensive study near Calling Lake originated from deciduous-dominated stands with 10-20%

* See Appendix 1 for definitions of selected status designations

White Spruce in the canopy, and less than 5% of records came from stands with >50% spruce in the canopy (F. Schmiegelow, unpubl. data). In the same study area, Black-throated Green Warblers did not use patches of aspen forest with few or no mature White Spruce (Robichaud and Villard 1999). Similarly, Westworth and Telfer (1993) showed an association of the species with conifers and Robichaud and Villard (1999) found that Black-throated Green Warbler territories appear to be located in areas with a higher conifer density than is available on average in deciduous-dominated mixed stands. There is also evidence that Paper Birch (Betula papyrifera) may be used preferentially over other deciduous tree species by Black-throated Green Warblers for foraging or nesting (Schieck et al. 1995, Robichaud and Villard 1999). The association of the Black-throated Green Warbler with mixed deciduous-coniferous stands appears to be characteristic of habitat used by the species in neighbouring areas in British Columbia (Cooper et al. 1997) and Saskatchewan (K. Hobson, pers. comm.) and has been supported in a broad analysis across Alberta, Saskatchewan and Manitoba (Kirk et al. 1996).

The age of forest stands also appears to influence their use by Black-throated Green Warblers. Near Lac La Biche, the Black-throated Green Warbler was found in significantly higher numbers in old (>120 years) aspen stands than in mature (51-63 years) or young (23-26 years) stands (Schieck et al. 1995). The species has also been found to be abundant in deciduous-dominated mixedwood forest 80-130 years old near Calling Lake (Schmiegelow et al. 1997, Robichaud and Villard 1999); less than 5% of records were from stands less than 90 years old (F. Schmiegelow, unpubl. data). Similarly, the Black-throated Green Warbler has been documented in 120-150 year-old White Spruce-dominated stands near Fort Vermilion (L. Takats, unpubl. data). In a study in the Boreal Foothills Natural Region, Black-throated Green Warblers reached their highest densities in 77 and 99 year-old mixed stands (Bighorn Environmental Design 1998), although older stands were not sampled. They were also found in immature mixed stands and old coniferous stands but not in young (37 years) mixed stands, nor in mature (86 years) stands of Logdepole Pine (Pinus contorta). Black-throated Green Warblers were almost totally absent from aspen stands less than 60 years old near Rocky Mountain House (Westworth and Telfer 1993). The Black-throated Green Warbler's use of individual spruce trees for singing and foraging increases significantly with increasing tree diameter (Robichaud and Villard 1999), which is correlated with stand age (Lee et al. 1995).

Other evidence corroborates the Black-throated Green Warbler's reliance on older stands. Both White Spruce and Paper Birch occur in greater abundance in the canopy of older stands, and, in fact, these tree species are two of the vegetative descriptors that most clearly distinguish mature from old stands (Lee et al. 1995). The Black-throated Green Warbler is also associated with the increasing canopy heterogeneity associated with older stands (Schieck and Nietfeld 1995), and uses small-scale (≥ 5 m diameter) canopy gaps more often than expected by chance (Smith and Dallman 1996). As a rule, old stands contain more such gaps than younger stands, both in aspen-dominated (Lee et al. 1995) and for conifer-dominated stands (e.g., Lertzman 1992).

CONSERVATION BIOLOGY

The Black-throated Green Warbler is the eastern representative of a widely dispersed superspecies, which includes the Golden-cheeked (D. chrysoparia), Hermit (D. occidentalis), and Townsend's (D. townsendi) Warblers (American Ornithologists' Union 1998). The Townsend's Warbler is the only other member of this group occurring in Alberta; hybrids of this species with Black-throated Green Warblers have been reported from British Columbia (Rohwer 1994). The Black-throated Green Warbler is further divided into two subspecies; the nominate form (D. v. virens) is the subspecies that occurs in Alberta and is by far the more widespread race. The other form (D. v. waynei) is known only from cypress swamps of the south-eastern United States.

The Black-throated Green Warbler is a small, foliage-gleaning wood warbler. Males and females are of similar size (11-12 cm long and weighing 8-11 g; Holmes 1986, Morse 1993), but males are more brightly coloured. Birds are reproductively mature in their first year, and first-year males are commonly known to breed (Morse 1993). Almost no data exist on longevity, but, based on a band return, the oldest bird on record was a minimum of 5 years and 11 months of age (Klimkiewicz et al. 1983).

The Black-throated Green Warbler is almost entirely insectivorous. Breeding birds tend to take a high volume of lepidopteran (butterfly and moth) larvae (Morse 1976), but will forage opportunistically on other abundant prey (e.g., midges along a lakeshore; Smith et al. 1998). This warbler is also known to consume beetles, true bugs, wasps, ants, gnats, moths, flies, spiders, and mites (Bent 1953) and, together, these other prey types may outnumber lepidopterans. Unlike several other related wood warbler species, the Black-throated Green Warbler is not known as a major predator of Spruce Budworms (Choristoneura fumiferana; a destructive pest of coniferous trees), except when the insect is at epidemic levels (Crawford et al. 1983). Most foraging by the Black-throated Green Warbler is diurnal, and primarily involves gleaning insects off leaves or small branches, but birds will also hover at branch tips and 'hawk' insects in mid-air. During wet weather individuals will forage more along the bark and trunks of trees (Morse 1976), and during migration they will also eat berries and other vegetative material (see Bent 1953). Both males and females forage quite high in the canopy: average heights of 13-15 m have been reported (Holmes 1986).

Black-throated Green Warblers arrive in Alberta from mid- to late-May (Pinel et al. 1993). Very few spring migrants are ever observed in southern Alberta, suggesting that most birds enter the province from the east (Salt 1973). Males arrive several days earlier than females, and immediately begin establishing territories by singing and exhibiting aggression towards other males. Territory size has been estimated at 0.25-0.90 ha in various habitats across the species' range (Morse 1976). In Alberta, 164 mapped territories averaged 0.81 ha (F. Schmiegelow, unpubl. data). Pair formation occurs shortly after the females' arrival, followed by nest building. Territory fidelity is not known for this species, but other Dendroica warblers have a 30-60% return rate the first year after banding, to within roughly 120 m of the previous nest site (see Holmes and Sherry 1992).

Very few Black-throated Green Warbler nests have been documented. The literature suggests that most nests are built in small or large coniferous trees, fairly close to the trunk (Salt and Salt 1976, Godfrey 1986, Morse 1993). Nests are built at a variety of heights from 1 m to 20 m (Bent 1953, Holmes 1986, Ehrlich et al. 1988, Semenchuk 1992), and there even exists one record of a ground-built nest (Brewster cited in Bent 1953). However, in a study in the southern boreal mixedwood forest of Alberta, five out of six nests found were in

deciduous trees (Robichaud and Villard 1999). Four of these were in birch trees, which may be important to Black-throated Green Warblers (see 'Habitat' section, above; Holmes and Robinson 1981, Morse 1993).

Little specific information exists on the breeding phenology of the Black-throated Green Warbler anywhere across its range, but this species is likely typical of other wood warblers. Clutches, which are likely initiated in mid-June, contain 3-5 eggs. The incubation period is roughly 12 days (Stanwood 1910, Pitelka 1940), and hatching is synchronous. Incubation and nestling care is almost entirely done by the female. Fledging occurs after 8-11 days (Stanwood 1910, Nice and Nice 1932, Bent 1953) and successful nests probably fledge 2-4 young (Morse 1993). Young can fly strongly within a few days of fledging at which point the adults may separate, each taking part of the brood. Young may remain with the parents for up to one month.

Fall migration in Alberta occurs between mid-August and mid-September (Salt 1973, Pinel et al. 1993). Many more Black-throated Green Warblers are observed in the fall migration than in spring in Alberta, and virtually all banding records for the province are from late August and early September, suggesting the species may follow different fall and spring migration routes. Black-throated Green Warblers, especially young birds, are often observed in mixed-species flocks of warblers. Birds turn up regularly, but in very low numbers, at Calgary (Sadler and Myers 1976, Pinel et al. 1993, D. Collister, pers. comm.). At a bird observatory in eastern North America it has been observed that hatch-year birds precede adults in the fall migration (Hall 1981), a pattern reversed from most wood warblers. Too few birds are observed on migration in Alberta to establish if this pattern also occurs here. All Black-throated Green Warblers likely leave the province before the third week of September.

Annual survivorship is not known, but is thought to be quite high. Morse (1989) estimated 67% annual survivorship based on comparison to other wood warblers with similar reproductive rates and patterns of migration. Red squirrels (Tamiasciurus canadensis) and Blue Jays (Cyanocitta cristata) have been identified as major predators of eggs and young (Morse 1993), and accipiter hawks likely take breeding adults. In northern Alberta, other corvids may also be important nest predators, although small mammals are probably responsible for more egg predation events in nests at lower heights (Cotterill 1996, Song 1998).

DISTRIBUTION

1. Alberta. - Alberta lies near the western and northern limits of the breeding distribution of the Black-throated Green Warbler. The species breeds in the forested portion of Alberta outside of the mountains (Figure 1). The limits of the Black-throated Green Warbler's breeding range roughly coincide with the limits of the Boreal Mixedwood and Boreal Foothills Ecoregions (see Strong and Leggat 1981). The most recent extensive survey effort, the Alberta Breeding Bird Atlas project (Semenchuk 1992), identified the Black-throated Green Warbler's range as the Peace River drainage from British Columbia to Wood Buffalo National Park, the lower Athabasca River drainage, and east to Cold Lake. The species was found in only 6% of atlas survey squares (10 by 10 km) in the boreal forest region. This distribution is largely in agreement with the previously published ranges by Salt (1973), Salt and Salt (1976), and Godfrey (1986). The Black-throated Green Warbler likely reaches its northern range limit in Alberta (i.e., south of 60°). The most northerly historic records are in the Caribou Mountains (Höhn and Burns 1975) and upper

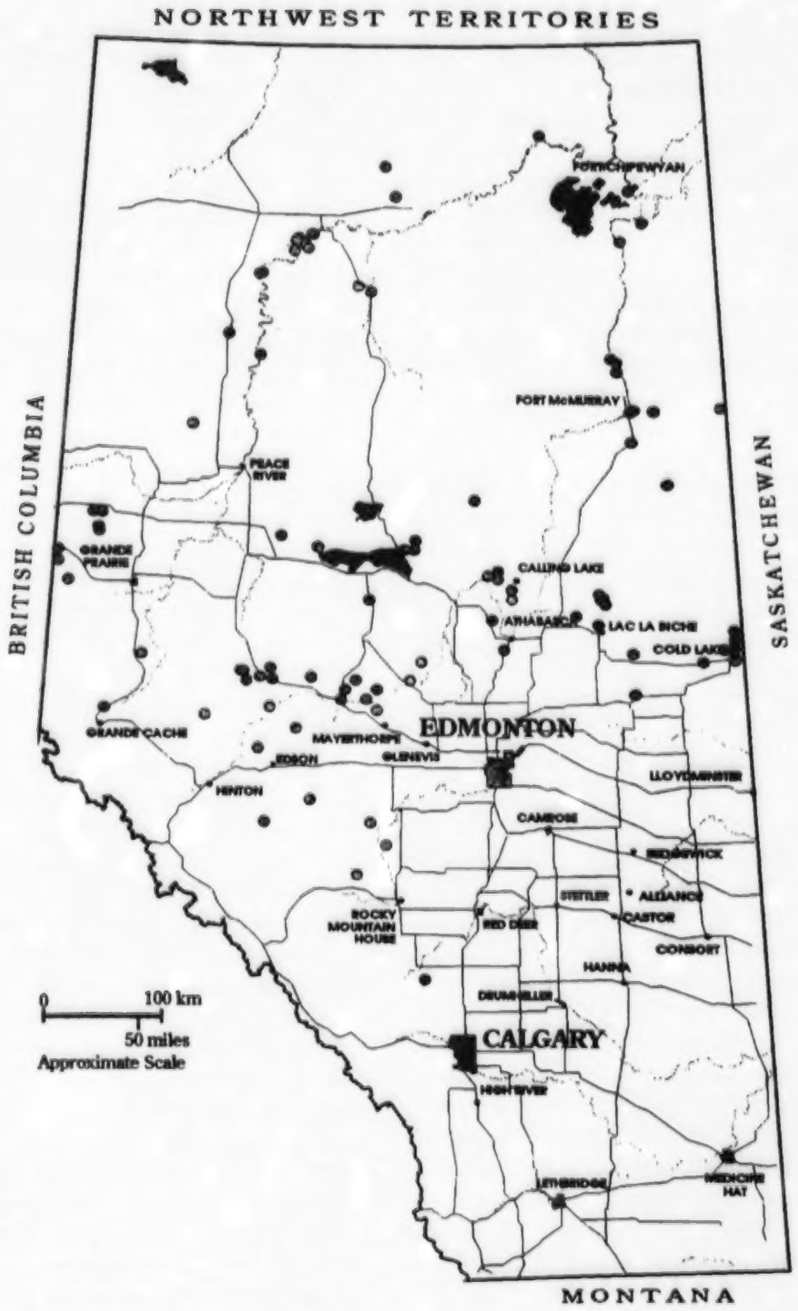

Figure 1. Records of Black-throated Green Warblers in Alberta. Details of individual records can be found in the Biodiversity/Species Observation Database maintained by Alberta Conservation Association and Alberta Environment.

Slave River Valley (Höhn 1971). The Alberta Breeding Bird Atlas project (Semenchuk 1992) confirmed these localities but did not extend the range farther north. A single, recent record from near Fort Chipewyan documents the species' presence in the Wood Buffalo region (B. Beck, pers. comm.). It is also likely that the species does not regularly breed in extreme northwest Alberta (e.g., Salt and Salt 1976, McGillivray and Hastings 1988, Semenchuk 1992), but virtually no data exist on the distribution of passerines in this region.

The Black-throated Green Warbler is known from the Peace River area of Alberta (Salt 1966, Gunn et al. 1975, S. Hellman, pers.comm., F. Schmiegelow, pers. comm.) and is found across the provincial border into British Columbia (Cooper et al. 1997). The species is reasonably common in the La Crete – Fort Vermilion area, and is regularly detected along the Peace River (L. Takats, unpubl. data, see Takats 1995).

The Black-throated Green Warbler has also been found at low density in the Rocky Mountain Foothills, although most published range maps exclude this natural subregion. Site records include Coal Valley (Pinel et al. 1993), and southeast to Medicine Lake (Westworth and Telfer 1993) and Brewster Creek (Bighorn Environmental Design Ltd. 1998). Farr (1995) did not detect any Black-throated Green Warblers in surveys in a variety of habitats near Hinton. There is one record of a Black-throated Green Warbler singing in the same drainage as Townsend's Warblers northwest of Grande Cache (D. Collister, pers. comm.). Black-throated Green Warblers are not known from the Rocky Mountains except as an extremely rare vagrant or migrant (Sharp 1973, Powell et al. 1975, Van Tighem 1981, Salt 1985). No records were obtained in a recent survey in the Rocky Mountain Foothills northwest of Nordegg (R. Brown, pers. comm.).

East of the foothills, the southern limit of the Black-throated Green Warbler's range in Alberta is coincident with the limit of the Boreal Mixedwood Ecoregion (see Strong and Leggat 1981) across a line from roughly Mayerthorpe to Cold Lake, where it is found in abundance (B. Beck, pers. comm.). The species is known to have nested previously, but not currently, at Glenevis (Pegg in Salt 1973, B. Beck, pers. comm.), and Edmonton (Macoun in Salt 1973), and may have nested further south in the Battle River region (Farley 1932). The absence of the species in this region suggests a slight northward contraction of its breeding range over the past few decades.

2. Other Areas. - The Black-throated Green Warbler's breeding range extends from the Peace River region of northeastern British Columbia, east across the southern boreal forest to Quebec and Labrador, and the Maritimes (Figure 2). Several sources suggest that the range of the Black-throated Green Warbler may extend north of 60° into the Northwest Territories (Salt 1973, Salt and Salt 1976, McGillivray and Semenchuk 1998). However, the species is listed only as a vagrant in western portions of the Northwest Territories (Sirois and McRae 1996), and has not been detected in recent surveys in the Liard River Valley nor in the Slave River lowlands (C. Machtans, pers. comm.). The southern limit of the Black-throated Green Warbler's continental breeding range extends just south of the Great Lakes, through the north-eastern United States, and south along the Appalachian Mountains. The subspecies D. v. waynei is confined to coastal areas of Virginia and the Carolinas (Figure 2). The continental breeding distribution of the Black-throated Green Warbler is not thought to have changed significantly, although the species had not been documented in north-eastern British Columbia prior to 1965 (Salt 1966).

Figure 2. Breeding and wintering distribution of the Black-throated Green Warbler in North America (adapted from Morse 1993).

The Black-throated Green Warbler winters primarily in eastern and southern Mexico and in Central America south to Panama. Wintering areas in the West Indies include Cuba, the Cayman Islands, the Bahamas, and Jamaica (American Ornithologists Union 1998). In more recent years, the Black-throated Green Warbler has been found wintering with increasing frequency in southern Texas and southern Florida (Morse 1993).

POPULATION SIZE AND TRENDS

1. Alberta. - There are no estimates of the population size of the Black-throated Green Warbler in Alberta as available data cover only local areas across a small portion of the species' provincial range. This warbler is usually described as being "sparsely and locally distributed" throughout its breeding range (Salt 1973, Semenchuk 1992). However, in at least some areas of suitable habitat, it can be quite common. Because most censuses of forest songbirds have been done using point-count and transect techniques, which identify and count birds based (mostly) on vocalizations of singing males (Bibby et al. 1992), absolute measures of density cannot be calculated (Verner 1985). Furthermore, comparisons across studies that used different methods, sampling intensities and levels of replication are of questionable validity. Nonetheless, some comparisons made on the basis of relative measures of abundance can be useful in the absence of more rigorous data.

Quantitative data on the abundance of the Black-throated Green Warbler exist only for the more southerly portion of its Alberta range. In old (>120 years) aspen-dominated mixedwood forest stands near Lac La Biche, the Black-throated Green Warbler was the sixth most abundant passerine, and the third most abundant wood warbler (Schieck and Nietfeld 1995). The same was true in 80-120 year-old stands near Calling Lake (Schmiegelow et al. 1997). In some stands near Calling Lake, the Black-throated Green Warbler was the third most abundant passerine (Norton and Hannon 1997). Near Grande Prairie and Peace River, it was the 10th and 9th most abundant species, respectively (W. Fleming, R. Naidoo, F. Schmiegelow, pers. comm.). In the Rocky Mountain Foothills, the Black-throated Green Warbler was the 17th most abundant passerine of 25 species in 60 year-old stands, and the 14th most abundant of 23 species in 80 year-old stands (Westworth and Telfer 1993).

Other areas within the Alberta breeding range of the Black-throated Green Warbler have not been systematically or comprehensively surveyed. However, it appears that population density is quite low over much of its range. Breeding Bird Surveys (BBS) rarely detect this species: only nine routes in Alberta have ever detected it, with a maximum count of two birds per route (Sauer et al. 1997, J. Park, pers. comm.). Inherent biases in BBS methodology and detectability for this species (Schieck 1997) undoubtedly influence this result. Similarly, past surveys in north-central Alberta have detected very few or no Black-throated Green Warblers: Erskine (1968) found only a single male near Webster Lake (east of Peace River), and Smith (1975) reported none on a survey between Utikuma Lake and Peerless Lake. Further north in the Caribou Mountains, Höhn and Burns (1975) reported only a single bird near Eva Lake, and Francis and Lumbis (1979) reported only two territories near Fort McKay. Recent surveys near Fort McMurray confirm the species' presence in low numbers there (R. Lauzon, pers. comm.).

There are no data that allow estimation of population trend in Alberta. BBS data are too sparse to calculate a trend estimate, although a range-wide trend map for the species suggests a decline of >1.5% per year in Alberta from

1966-1996 (Sauer et al. 1997). All that can be concluded is that the Black-throated Green Warbler appears to be sparsely distributed over large portions of its range, but that there are at least some areas where it is locally quite abundant.

2. Other areas. - There are no general estimates of the population size of the Black-throated Green Warbler from throughout its breeding range. Reported population densities from other parts of Canada range from 0.06 birds/ha to 0.67 birds/ha (Erskine 1977). In the United States, densities of 0.9 birds/ha to 4.0 birds/ha have been documented (Morse 1993). In some areas the Black-throated Green Warbler is among the more common passerines. In a long-term study in New Hampshire, Black-throated Green Warblers were found to have one of the most stable population densities of any species over a 16-year period (Holmes et al. 1986).

Overall numbers detected by BBS have remained relatively constant over the period 1966-1996. The survey-wide and Canada-wide results show no statistically significant increase or decrease over this time period (0.0% survey-wide, -0.1% Canada; Sauer et al. 1997), although the species has shown upward and downward trends over shorter time periods (Peterjohn and Sauer 1994). Within the closed Boreal Forest Region, which is limited to Canada and includes northern Alberta, populations have declined by 0.6%/year since 1966, with a more rapid decline of 2.3%/year in 1980-1996, although these decreases were not statistically significant.

In Saskatchewan, few data exist, but at two sites Black-throated Green Warblers decreased by 67-76% between 1973 and 1990 (Kirk et al. 1997). Kirk et al. (1997) identified Black-throated Green Warblers as one of five species of greatest concern in that province based on the magnitude of population declines. There are no population trend data for British Columbia. In general, there has been concern expressed over declining populations of many neotropical migratory songbirds across North America (e.g., Terborgh 1989).

LIMITING FACTORS

There is considerable debate in the scientific literature as to the relative significance of events occurring on breeding, wintering, and migratory stopover habitats in terms of their effects on songbird populations (e.g., Böhning-Gaese et al. 1993, Rappole and McDonald 1994). For the purposes of this report, this section will mainly deal with events occurring in Alberta, within the breeding range of the Black-throated Green Warbler.

1. Habitat Loss and Fragmentation. - The loss and fragmentation of forest habitat are closely allied processes. 'Habitat loss' refers to the conversion of suitable habitat into unsuitable habitat, while 'fragmentation' is the increasing isolation and division of remaining habitat. Habitat fragmentation has been implicated in the declines of neotropical migratory songbird populations across North America (Robbins et al. 1989, Terborgh 1989). As the area of patches of suitable habitat declines, and the distances between those patches increases, the likelihood of individual patches supporting a subpopulation of birds declines (Saunders et al. 1991, Villard et al. 1995). There is little data available on individual species, but it is reasonable to assume that Black-throated Green Warblers will respond to habitat fragmentation in a similar fashion as other neotropical migrants. Black-throated Green Warblers may also actively avoid edge habitats associated with forest harvesting (Germaine et al. 1997) and be reluctant to cross habitat openings (Rail et al. 1997) as has been shown for other species

of songbirds (Desrochers and Hannon 1997). In eastern North America, local extirpations of the Black-throated Green Warbler have been documented in heavily fragmented forests (e.g., Askins and Philbrick 1987, Litwin and Smith 1992). Much of our understanding of the effects of forest fragmentation on birds developed from studies in agricultural landscapes in eastern North America, but recent research in Alberta is shows similar but less severe results (e.g., Schmiegelow and Hannon 1993). In an area of northern Alberta where much of the landscape remains forested, Black-throated Green Warblers have declined by roughly 50% in forest fragments only five years after harvesting (Schmiegelow and Hannon, in press).

These factors together (habitat loss, fragmentation, and edge avoidance) may lower bird reproductive success in fragmented forests by influencing pairing success (Gibbs and Faaborg 1990, Villard et al. 1993) or other factors (see 'Nest Predation and Parasitism', below). However, no specific studies have been conducted on Black-throated Green Warblers in relation to these factors. Habitat corridors may facilitate bird dispersal in a fragmented landscape, but there is likely to be a critical threshold in the degree of landscape fragmentation beyond which populations may decline more rapidly (With and Crist 1995). Overall, it is thought that the effects of habitat loss outweigh the effects of habitat fragmentation (Fahrig 1997). Thus, although the two processes are clearly linked, conservation efforts are probably best directed at slowing the rate of direct habitat loss.

2. Agriculture. - Agricultural, as well as urban, expansion may be implicated in the possible northward contraction of the Black-throated Green Warbler's breeding range. In the Alberta breeding range of the Black-throated Green Warbler, agriculture is largely limited to part of the Peace River drainage, and a smaller part of the Athabasca River drainage. In the Peace Country, 45 000 km^2 (~12%) of the land is in agricultural production. However, agricultural expansion in this area is nearing its limits as all economically viable land is already in use (MacLock et al. 1996).

3. Forest Management. - Timber harvesting has increased significantly in Alberta in recent years. Until relatively recently, most harvesting by the forestry sector was focussed on coniferous stands, but as of the mid-1980s, deciduous and mixedwood forests have also come under pressure. Large forested areas have been allocated to forest companies under Forest Management Agreements (FMAs). As of December 1995, there were 11 FMA holders in Alberta covering more than 13.6 million ha of the province's forested area (Alberta Environmental Protection 1996); by November 1998 this had increased to 17 FMA holders covering roughly 19.6 million hectares (D. Price, pers. comm.). These figures represent 60% and 87% allocation of the province's landbase, respectively. The proportion of the Annual Allowable Cut (AAC) allocated has also steadily increased. As of January 1995, roughly 85% of the province's AAC of timber had been allocated (94% coniferous, 73% deciduous), and the provincial government anticipates further increases in allocation and harvesting (Alberta Environmental Protection 1996). Between 1990-96, approximately 58 000 ha of forest were harvested annually (Natural Resources Canada 1998), representing roughly 1% of the commercially productive landbase.

Black-throated Green Warbler habitat will likely be reduced in quantity and quality under the current forest harvesting strategies. Current operating ground rules for forestry in the province dictate a two- or three-pass clearcutting system, with the oldest stands prioritized for harvest (Alberta Environmental Protection 1994). Furthermore, with rotation lengths of 60-80 years, stands won't be allowed to reach an age where they will support Black-throated Green Warblers (see 'Habitat' section, above). Overall, current forest harvesting strategies will lead to a reduction in the proportion of old stands in the landscape, and will fragment previously contiguous forest. Cumming et al. (1994) estimated that habitat availability for the Black-throated Green Warbler could be reduced by 75-95% over a 300 year time horizon, depending on the harvest rate and other factors, with reductions of 50-70% forecast over the next 100 years.

Two current government policies in Alberta favour the elimination of mixedwood stands - the preferred habitat of the Black-throated Green Warbler (Cumming et al. 1994). First, after mixedwood stands are harvested, they are typically reforested to pure coniferous or deciduous species following predetermined regeneration standards. Secondly, harvesting of deciduous-dominated stands every 60-80 years (Alberta Environmental Protection 1994) prevents these stands from reaching an age at which spruce trees reach the canopy (Lee et al. 1995). Both these policies contribute to the phenomenon of 'unmixing of the mixedwood', at the cost of suitable Black-throated Green Warbler habitat. Management of mixed stands may change in the future, however, with an increasing recognition of their value and a better understanding of management options (Peterson and Peterson 1992).

Increasingly, consideration is being given to modified harvest strategies, involving the retention of vegetation structure for wildlife habitat as an alternative to clearcutting. In one study of variable tree retention, Black-throated Green Warblers declined precipitously the year following harvest, even with tree retention rates of up to 40% (Norton and Hannon 1997). The species was absent from all harvested sites after three years (Tittler 1998). The Black-throated Green Warbler has also been shown to avoid heavily thinned and strip-cut sites (Freedman et al. 1981), and areas of forest containing small patch cuts (Germaine et al. 1997). However, other work indicates that the Black-throated Green Warbler can be found in small but intact patches of trees within harvested sites. Birds have been found in patches of 0.1-0.5 ha (200-400 mature trees) surrounded by 30-60 year-old regrowing forest, and occasionally in smaller patches (as low as 0.01 ha, J. Schieck, unpubl. data). Reproductive output of birds in these areas is not known.

4. Energy Sector Activities. - Oil and gas development in the forested region of Alberta impacts the landscape through the clearing of forest for seismic exploration lines, pipelines, and wellheads. Currently, roughly 14 000 km of new seismic lines are cut each year, and an additional 20 000 km of existing lines are re-cleared annually (R. Jamieson, pers. comm.). At an average width of 6 m, this translates to approximately 8400 ha of new forest cutting annually, and 12 000 ha of forest being re-opened. Thus, the total amount of forest harvested annually by the oil and gas sector is substantially less than by the forest industry. However, due to the linear nature of these disturbances, the total area of forest that is affected may be significantly higher. This adds to the impacts of forestry in causing habitat loss, and further reduces the availability of forest undisturbed by human activities as well as creating semi-permanent open corridors into forested landscapes (see below).

5. Nest Predation and Parasitism. - In the heavily fragmented landscapes of eastern North America, where agriculture is the dominant land-use, predation and parasitism of nests is thought to be a significant limiting factor of songbird populations (Andrén 1992, Donovan et al. 1995, Robinson et al. 1995). The Brown-

headed Cowbird (Molthrus ater) regularly parasitizes nests of neotropical migrant songbirds, and predation of eggs by corvids can be significant. Black-throated Green Warblers are known to be regular hosts for cowbirds in the east (Morse 1993). Studies in boreal Alberta suggest that, over the short-term, neither predation nor parasitism rates increase following forest fragmentation from logging (Cotterill 1996, Song 1998), but whether the predator community or cowbirds simply hadn't yet responded to recent harvesting in these studies is unknown. Cowbirds and corvids are currently present at low densities in this region. However, species such as the Brown-headed Cowbird may gain access to forested landscapes via linear corridors, such as resource extraction roads and seismic lines (Askins 1994). Edge habitats, which may facilitate predation or parasitism, are short lived adjacent to cutblocks, but are longer-term features associated with linear disturbances. Song (1998) found slight evidence that nest predation by red squirrels is higher along seismic lines than at other types of edges. Most nest predation events were attributed to small mammals, whose response to habitat may be complex, and may be species- and habitat-specific (Bayne and Hobson 1998).

6. Winter and Migration Stopover Habitat. - Winter habitat degradation is likely a significant factor affecting songbird populations (Sherry and Holmes 1993) and may, in fact, be more significant than factors on the breeding grounds (Rappole and McDonald 1994). Forest habitats in the wintering range of most North American songbirds are being depleted at an alarming rate: forest loss in Central America has been estimated at 2% annually (Hartshorn 1992). However, the Black-throated Green Warbler may be less vulnerable to tropical deforestation than some other species because of its broad range of winter habitat use (Morton 1992). The species has been observed using logged areas (Lynch 1989) and canopy trees over coffee plantations (Terborgh 1989), suggesting that it is not particularly sensitive to human disturbance during the non-breeding season.

Little is known about the habitat requirements of the Black-throated Green Warbler during migration. In fact, there is no documentation available on its migratory routes or frequently used stopover sites. However, the importance of migratory stopover sites is becoming recognized (Hutto 1998).

STATUS DESIGNATIONS

1. Alberta. - In a 1991 review of the status of wildlife species in Alberta, the Black-throated Green Warbler was placed on the 'Yellow List' of sensitive species that are not at risk in the province (Alberta Fish and Wildlife 1991). In 1996, the species was upgraded to the 'Blue List' of species that may be at risk of long-term declines to non-viable population levels (Alberta Wildlife Management Division 1996). This designation was made based on concerns over anticipated population declines in some areas coupled with habitat loss in the face of forest harvesting. The Black-throated Green Warbler is not presently on the Alberta Natural Heritage Information Centre's Tracking or Watch List (Alberta Natural Heritage Information Centre 1999).

In a conservation and management priority-setting exercise, the Black-throated Green Warbler was ranked seventeenth out of 232 landbird species in Alberta in terms of 'provincial supervisory responsibility' (Dunn 1997). It was the twelfth ranked songbird, and the eighth ranked of predominantly forest-breeding songbirds (there are roughly 112 species of songbirds that breed in Alberta). This ranking reflects both the species' extensive geographic range in the province

combined with potential threats to its persistence.

2. Other Areas. - The Black-throated Green Warbler has not been considered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Natural Heritage Programs assess the conservation status of all the species and ecosystems in their databases, and provide ranks based on a globally congruous set of criteria (Appendix 1, see The Nature Conservancy 1999 and associated links). The Natural Heritage Element Rarity Rank for the Black-throated Green Warbler is G5 or 'demonstrably secure' throughout its global range (The Nature Conservancy 1999). In British Columbia, the Black-throated Green Warbler is ranked as S2 or 'imperiled' and is on the 'Red List' of vulnerable or sensitive species (Cooper et al. 1997, B.C. Wildlife Branch 1999). The Black-throated Green Warbler's restricted distribution and threats to its habitat (similar to those in Alberta) were cited as reasons for the recommended status. In Saskatchewan, the Black-throated Green Warbler is ranked as S4, or 'apparently secure', and is similarly ranked in other jurisdictions in Canada.

The Canadian Wildlife Service gave the Black-throated Green Warbler a 'Canadian supervisory responsibility' score of 'high' and a 'preliminary Canadian concern' rating of 'medium' (Dunn 1997). The high rating for supervisory responsibility is largely a reflection of the bulk of the species' breeding range occurring in Canada, while the concern rating reflects perceived threats to the species. The species was consistently a 'high' species in terms of conservation and management priorities for all provinces (ranked 6-32 out of 128-232 species) except British Columbia, where it ranked low due to its restricted range in that province (Dunn 1997).

RECENT MANAGEMENT IN ALBERTA

No specific management activities have been reported for this species in Alberta. However, several major research initiatives on forest management are underway in the province that include a songbird component:

- Sustainable Forest Management Network (SFMN)

The aim of the SFMN is to develop strategies that align economic and environmental objectives to ensure that Canada's boreal forest is effectively managed, that its biological diversity is preserved, and that its resources are sustained for future generations (V. Adamowicz, pers. comm.).

- Terrestrial and Riparian Organisms, Lakes and Streams (TROLS)

The TROLS study is the first and most comprehensive study ever undertaken to investigate the full implications of forested buffer strips on the conservation of both aquatic and terrestrial communities in northern Alberta (E. Prepas, pers. comm.).

- Calling Lake Project

This project consists of a complimentary group of experimental and mensurative studies aimed at assessing the effect of harvesting of the boreal mixedwood forest on the community composition and structure of forest songbirds. The studies address various fragmentation issues, utilization of the continuum of older deciduous, mixed and coniferous forest types, and colonization patterns in recently harvested areas. Work was initiated in 1993 and is ongoing (F. Schmiegelow, pers. comm.).

- Ecosystem Management by Emulating Natural Disturbance (EMEND)

The overall objectives of the EMEND project are 1) to determine which forest harvest and regenerative practices best maintain biotic communities, spatial patterns of forest structure, functional ecosystem integrity in comparison with mixed-wood landscapes that have originated through wildfire and other inherent natural disturbances; and 2) to employ economic and social analyses to evaluate these practices in terms of economical viability, sustainability and social acceptability (J. Spence, pers. comm.).

A number of policy documents exist that are designed to guide forest management activities in a sustainable way. The Alberta Forest Conservation Strategy, the Forest Management Planning Manual, and the Canadian Forest Accord all incorporate biological conservation as a central ideal. Also, the conservation of biological diversity is the first criterion of sustainable forestry listed by the Canadian Council of Forest Ministers. Thus, some policy background exists on which to move research findings into management actions.

SYNTHESIS

The population trend of the Black-throated Green Warbler is unknown in Alberta, but populations appear to be fairly stable. Population size is unknown but may be quite large. The distribution of the species in the province may be experiencing a slight northward contraction.

Some excellent research regarding forest management practices and their effects on bird communities is already underway in Alberta. There are no ongoing studies specifically on the Black-throated Green Warbler, but the species will be covered by many community-level projects. However, most work is confined to the southern boreal and Peace River areas of Alberta. Larger scale surveys across the poorly known northern boreal zone, while expensive and logistically difficult would generate valuable basic information on the distribution and abundance of this and other songbird species. Long-term, standardized studies (such as the Calling Lake Project) will be crucial in determining the provincial trend of the Black-throated Green Warbler. A detailed characterization of the Black-throated Green Warbler's habitat use across all forest types used by the species could quantify features it requires (e.g., stand ages, tree species density and distribution). Since a reduction in the rate of forest harvest and clearing is unlikely in the near future, modifications to harvest practices forest management policy to guarantee the continued availability of suitable habitat should be pursued.

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APPENDIX 1. Definitions of selected legal and protective designations.

A. Status of Alberta Wildlife colour lists (after Alberta Wildlife Management Division 1996)

Red	Current knowledge suggests that these species are at risk. These species have declined, or are in immediate danger of declining, to nonviable population size
Blue	Current knowledge suggests that these species may be at risk. These species have undergone non-cyclical declines in population or habitat, or reductions in provincial distribution
Yellow	Species that are not currently at risk, but may require special management to address concerns related to naturally low populations, limited provincial distributions, or demographic/life history features that make them vulnerable to human-related changes in the environment
Green	Species not considered to be at risk. Populations are stable and key habitats are generally secure
Undetermined	Species not known to be at risk, but insufficient information is available to determine status

B. Alberta Wildlife Act

Species designated as 'endangered' under the Alberta Wildlife Act include those defined as 'endangered' or 'threatened' by *A Policy for the Management of Threatened Wildlife in Alberta* (Alberta Fish and Wildlife 1985):

Endangered	A species whose present existence in Alberta is in danger of extinction within the next decade
Threatened	A species that is likely to become endangered if the factors causing its vulnerability are not reversed

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 1999)

Extirpated	A species no longer existing in the wild in Canada, but occurring elsewhere
Endangered	A species facing imminent extirpation or extinction
Threatened	A species likely to become endangered if limiting factors are not reversed
Vulnerable	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events
Not at Risk	A species that has been evaluated and found not to be at risk
Indeterminate	A species for which there is insufficient scientific information to support status designation

D. United States Endangered Species Act (after National Research Council 1995)

Endangered	Any species which is in danger of extinction throughout all or a significant portion of its range
Threatened	Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range

E. Natural Heritage Element Rarity Ranks (after The Nature Conservancy 1999)

Global or G-rank: Based on the range-wide status of a species.
Sub-national or S-rank: Based on the status of a species in an individual state or province. S-ranks may differ between states or provinces based on the relative abundance of a species in each state or province.

G1 / S1	Critically imperiled because of extreme rarity (5 or fewer occurrences, or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extinction
G2 / S2	Imperiled because of rarity (6 to 20 occurrences), or because of other factors demonstrably making it very vulnerable to extinction throughout its range
G3 / S3	Either very rare or local throughout its range, or found locally in a restrcited range (21 to 100 occurrences)
G4 / S4	Apparently secure, though it might be quite rare in parts of its range, especially at the periphery
G5 / S5	Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery

B - A rank modifier indicating breeding status for a migratory species.
N -A rank modifier indicating non-breeding status for a migratory species.

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